Energy consumption

Forecasting

Linear regression

[1] present the estimation of price and GDP consumption elasticities. The second target is to provide an accurate model for electricity consumption forecasting. Multiple linear regressions using GDP and population as selected variables to forecast electricity consumption in Italy up to 2030 are presented. Moreover a simplification is proposed considering regression models using the ratio between GDP and population (GDP per capita) as independent variable.

Time series forecasting

[3]presents a comprehensive review of the existing machine learning techniques for forecasting time series energy consumption. This paper show the nine popular forecasting techniques that are based on the machine learning platform. The objective of this paper are to perform a comparative analysis that includes both qualitative and quantitative aspects of these techniques.

Model	No. of papers reviewed	Publication year range	Year with maximum publications
ANN	17	1996–2015	2015
ARIMA	22	1992–2015	2011
SVM	19	2004–2015	2009
CBR	2	2013–2014	2013
Fuzzy	12	1998–2015	2015
Grey	13	2003–2015	2012
MA & ES	11	1971–2015	2013
NN	9	2004–2015	2014
Hybrid	61	1996–2015	2015

Table 1 Summary of papers reviewed.

Time series technique

The analysis of time series can be divided into two parts. The first part is to obtain the structure and underlying pattern of the observed data. The second part concerns with fitting a model to make future predictions. Time series analysis is used for many applications including economic forecasting, process and quality control, census analysis etc.[4]

1. Trend – The general movement that the variable exhibits during the observation period without taking the seasonality and irregularities into account.

2. Seasonality – This is the periodic fluctuation of the variable subjected to analysis. It consists of effects that are stable along with time, magnitude and direction.

3. Residual – This is the remaining, mostly unexplainable part of the time series. These can be sometimes high enough to mask the trend and seasonality.

Model	Advantages	Disadvantages
ANN	1. Ability to precisely map input and output relationships 2. Performance well for non-linear time series 3. More general and flexible	1. Depends on initialization of weight values 2. Problem of the local minima 3. Overfitting and difficult to generalize
ARIMA	1. Uses lag and shift of historical data 2. Regression model with a moving average (improves accuracy) 3. Provides confidence intervals on predictions with reliability	1. Model identification is difficult 2. Not suitable for long-term prediction 3. Does not fully capture the non-linear patterns of the series
SVM	1. Good for fitting and generalization 2. Performs well for long-term time series 3. Use of a kernel function introduces nonlinearity and deals with arbitrarily structured data	1. Lack of transparency of results 2. Finding optimum parameters can be a computational burden as number of parameters and size of dataset increases
CBR	1. Similar to human cognitive processes 2. Doesn't need to find rules between parameters of the problem	1. Needs introduction of new aspects, e.g. case representation for time series processing 2. Needs huge data
Fuzzy	1. Close to human experience via membership functions and rules. 2. Good for solving uncertainties in load forecasting	1. Temporal patterns are defined by rigid regions, hard to adjust with noise 2. High computational complexity and lacks stability
Grey	1. Capable of predicting with limited data and incomplete information 2. Easy to compute and calculate	1. Inadequate in recognizing random component 2. Problem with conventional approach of model validation
MA & ES	1. Simplicity in calculations 2. The use of low number of observations 3. Transparency in approach	1. Poor results compared to sophisticated techniques 2. Not suitable for long-term and non-linear prediction
NN	1. Simple process with no explicit training step required 2. Intuitive and ease of implementation	1. Function is often approximated only locally 2. Challenging to compute exact number of nearest neighbors
Hybrid	1. Complimentary combination of different machine learning methods 2. Robust for complex problems and often improves performance	1. High model complexity 2. Computational intensive 3. Often difficult to identify which methods to combine

Table 2 Summary of qualitative comparison for the 9 major time series forecasting techniques.

Prediction

Support vector regression

[5] propose Vector field-based support vector regression for building energy consumption prediction and the result indicate that the proposed method achieves better performance than commonly used methods with regard to the accuracy, robustness, and generalization ability.
Grey Model and Multiple regression
[7] presents grey model (GM), multiple regression model (MRM) and the integration model of grey model and multiple regression model (IGMMRM) to forecast the number and trend of energy consumption in Zhejiang to promote the sustainable energy development.

Fault Detection Analysis

[6]describes three different data mining techniques for detecting abnormal lighting energy consumption using hourly recorded energy consumption and peak demand (maximum power) data.A classification and clustering of hourly recorded data using CART, K-Means and DBSCAN algorithms respectively have been carried out.

Network Model

[8]develops an energy consumption network model with the method of social network analysis. The empirical results may be helpful in guiding policy makers in devising long term sustainable plans. They selected input-output data of 42 industrial sectors from Chinese-2007.

Evaluation

[2] develop evaluation methodology for finding features of energy provision and consumption from observed data based on four plants data.(data envelopment analysis).This method has chance to recommend the best energy consumption system matched to each plant. For example,“The supply system of E1 type works well in the region where the water temperature is low”

Other

[9]utilizes the logarithmic mean Divisia index method (LMDI) additive decomposition method to identify the main factors driving energy consumption in China's NMI during the 2000—2014 period. The change in energy consumption in China's NMI is decomposed into five factors: energy structure, energy intensity, industrial structure, labour productivity and industrial scale.

[10]the multiple regression models of energy consumption based on Trnsys simulation results were established. Then the appropriate energy-saving applications of building envelope were discussed in different climates.

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